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FOR

NEUTRAL SECTION

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NEUTRAL SECTION

The present invention relates to a neutral section for use in conjunction with railway overhead conductor lines.

Electric trains are powered through overhead copper conductor lines, the power being conveyed via a pantograph attached to the roof of the train. The conductor lines are usually powered by 25kV AC supplied from power stations along the route of the lines. As the power stations are not synchronised, a peak-to-peak difference of up to 50kV AC can occur where two power supplies meet along the length of a conductor line. It is important to ensure that the pantograph does not register the difference in power supplies as otherwise a large electrical load would be placed on it, which could damage it and other electrical equipment in the train. As it is impractical to synchronise the power stations, they are normally isolated from each other by the provision of an assembly known as a neutral section on each conductor line.

It is desirable that the pantograph does not detect the presence of the neutral section on the conductor lines as, apart from electrical loading, it would then also be subject to variable reaction forces, which would be conveyed to the train to cause "bumping".

The neutral sections that are currently on the market include those provided by Siemens GmbH, Arthur Flury AG and Furrer & Frey AG. The neutral section of Siemens GmbH, consisting of two insulator rods mounted on plates with copper conductors being clamped thereto, is mechanically quite different from the conductors and increases the scope of shock loading on the pantograph. Although the height of the neutral section can be adjusted relative to the copper conductors in order to align them as closely as possible in the vertical plane, the catenary member that is used for such adjustment makes the neutral section assembly more bulky, increases its structural and mechanical difference from the conductor lines, and complicates its installation. An arcing horn is provided in this neutral section to channel the power dissipation that occurs if the pantograph registers the difference in power supplies. However, it is not particularly effective in this role, as often sparks are seen to form where the pantograph attaches to the neutral section. Furthermore, this neutral section is expensive, wears quickly (it needs to be replaced roughly every eight months), and requires monthly maintenance to turn the insulator sections (which wear out by virtue of point contact with the pantograph).

Accordingly, it is desirable to provide a neutral section that effectively isolates the conductor lines without posing a “gap” to a pantograph traversing the length of the lines, is maintenance-free during the lifetime of the product, cheap to produce and simple to install.

According to an embodiment of the present invention, there is provided a neutral section for use with an overhead railway conductor line, which neutral section is disposed between the ends of the conductor line when in use and comprises an insulator to isolate the ends of the conductor line from each other; wherein the neutral axis of the neutral section is such that when the neutral section is in use the neutral axis is aligned closely with the neutral axis of the conductors on its either side and the height of the insulator is chosen so that the stiffness and the dynamic mass of the neutral section closely match those of the conductors on its either side in both the vertical and horizontal planes.

The structural and mechanical profile of a neutral section embodying the present invention is constructed to closely correspond with that of railway overhead copper conductor lines in order to minimise the scope of being registered by a pantograph, this being achieved by closely aligning the neutral axes (median bending line) of the neutral section and the conductors on its either side, and by closely matching the stiffness and the dynamic mass of the neutral section and the conductors in both the vertical and horizontal planes.

An embodiment of the present invention provides a continuous running surface to the pantograph that is both coplanar with the conductors on its either side (so that the pantograph is not subject to shock loading) and narrow (since misalignment with the pantograph would cause a severe twisting action in the neutral section), and also provides the advantage that the drag imposed by the neutral section on the pantograph is equal to, or less than, that exerted on it by the conductors.

Furthermore, an embodiment of the present invention provides isolation over a distance in excess of 1.5m, even when the pantograph (which is 0.2m in width) attaches to the neutral section and effectively increases its length to about 1.7m.

An embodiment of the present invention is capable of withstanding the 15kN loads, which are hung every few hundred metres along the length of the conductor lines in order to provide tension, without degrading.

An embodiment of the present invention provides all the above-discussed advantages in adverse environmental conditions such as rain, snow, contamination, etc.

Reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 shows a neutral section embodying the present invention;
Figure 2 shows a part of a neutral section embodying the present invention;
Figure 3 is a more detailed drawing of Figure 2;
Figure 4 shows a connection member used in an embodiment of the present invention;
Figure 5 shows a neutral section embodying the present invention;
Figure 6 shows front and side views of the neutral section shown in Figure 5;
Figure 7 shows how the PTFE rails are arranged in an embodiment of the present invention; and
Figure 8 shows an embodiment of the present invention with a modified surface.

Figure 1 shows a neutral section 1 embodying the present invention. The neutral section 1 includes an elongate insulator 10 moulded from an insulating material such as a glass-fibre reinforced epoxy composite with a 45% glass fraction. The outer surface of the insulator 10 can be chemically treated or coated with a paint to improve its shedding ability and be generally resilient in adverse environmental conditions.

The neutral section 1 also contains a connection member 2 by way of which it connects to adjacent conductor ends. As shown in Figures 2 and 3, in one embodiment of the present invention, the connection member 2 is a U-shaped copper member embedded within the insulator 10 with its legs 3, 4 (hereinafter referred to as conductor tails) protruding therefrom and lying adjacent to the conductors on either side of the insulator 10. One of the conductor tails 4 is connected to an end of the conductor line using conventional splices, for example, whilst the other conductor tail 3, although usually redundant, can be used as an arcing horn if required. If there is any wear on the conductor section into which the neutral section is being fitted, the end face of the connecting conductor tail 4 can be filed accordingly so that a step height change between the neutral section and the conductor section can be avoided.

A connection member 2 used in an embodiment of the present invention is shown in more detail in Figure 4 in which Figure 4a is a perspective view, Figure 4b is a front view and Figure 4c is a side view. As can be seen most clearly from Figure 4a, pegs 5 are provided on the surface of the connection member 2, equally spaced apart and so as to protrude from the outer surfaces of the conductor tails 3, 4 at corresponding positions. The pegs 5 are driven through the surfaces of the conductor tails 3, 4, before the connection member 2 is placed in the insulator mould. When the mould sets, the pegs 5 remain firmly lodged in the insulator walls, thus ensuring that the connection member 2 is held strongly within.

In one embodiment of the present invention, the dimensions indicated in Figure 4 may be as follows: a1=30mm, a2=100mm, a3=17.09mm, a4=200mm, b1=46mm, b2=34.19mm, b3=22.37mm, c1=20mm, c2=10mm, and d=2.5mm. In addition, in such an embodiment, the radii of curvature e and f are 23mm and 11.19mm, respectively.

In an embodiment of the present invention, the profile of the neutral section 1 is matched with those of the copper conductors with which it is to be used on its either side by aligning the neutral axes of the neutral section 1 and the copper conductors. This is achieved by designing the profile of the neutral section 1 such that its neutral axis is as low as reasonably practical, such as, for example, to lie only 12mm above the neutral axis of adjacent conductors. Furthermore, the height of the insulator is increased so that the stiffness of the neutral section 1 matches that of the conductors on its either side in both the vertical and horizontal planes.

To achieve these criteria, a neutral section 1 embodying the present invention can be designed as shown in Figure 5, in which Figure 5a is a front view of the neutral section 1, Figures 5b, 5c and 5d are cross-sections respectively taken on line A-A, line B-B, and line C-C, and Figure 5e shows an outer view of one face of the neutral section 1. As most clearly seen from Figures 5b to 5d, when in use, the profile of the neutral section 1 would be streamlined with those of the conductors lying adjacent to it.

In one embodiment of the present invention, the dimensions indicated in Figure 5 are as follows: g1=24.5mm, g2=20.71mm, g3=12mm, g4=37.6mm, g5=49mm, g6=46.52mm, g7=60mm, g8=147.59mm, g9=52.41mm, g10=47.59mm, h1=10mm, h2=19.5mm, h3=25.93mm, h4=29mm, h5=18.05mm, h6=33mm, h7=19.24mm, h8=23mm, and h9=46mm. In addition, in such an embodiment, the angle i of the

sidewalls of the neutral section 1 is 12°. The radii of curvature in this embodiment are as follows: j1=5mm, j2=5mm, j3=1.5mm, j4=200mm, j5=24.5mm, j6=8mm, j7=11.19mm, j8=22.06mm, j9=8mm, j10=1.5mm, j11=1.5mm and j12=8mm.

Figure 6a and 6b show respective front and side views of an embodiment of the present invention. As can be seen from Figure 6a, two rails 6, 7 are embedded in the running surface of the neutral section 1. As these rails 6, 7 lie parallel to the conductor at each end of the neutral section 1, they provide a continuous surface against which the pantograph can run. By virtue of being made of a low friction material, such as PTFE, the rails pose less frictional drag to the pantograph compared to when it traverses the length of the conductors, thus helping to reduce wear of the pantograph and insulator 10. The wear characteristics of the rails can be improved by incorporating glass beads in the PTFE. As the ends of the neutral section 1 are turned up in a vertical direction, so too are the leading ends of the rails 6, 7, (as can be seen most clearly in Figure 7) which ensures that the pantograph attaches to the rails 6, 7 without hitting them. Furthermore, by virtue of being guided by the conductor tails 3, 4, onto the rails 6, 7, the pantograph attaches to the neutral section 1 in a fluid and smooth manner.

In one embodiment of the present invention, the dimensions indicated in Figure 6 are as follows: k1=1706mm, k2=200mm, k3=100mm, k4=21.6mm, k5=37.6mm, k6=49mm, l1=57.5mm, l2=18.43mm, and l3=23mm.

Figure 8 shows an embodiment of the present invention with a modified surface. Specifically, a semiconductor tape is attached to the spine of the neutral section 1, which has the effect of spreading the excess charge associated with arcing by conducting it along the length of the neutral section 1. Furthermore, electrical plates (barriers) 11 or "sheds" are attached to the spine of the neutral section 1 in order to increase the effective electrical path length of the neutral section 1. In an embodiment of the present invention, the barriers are made from epoxy resin with chopped strand glass fibre reinforcement. However, they could be made of any other appropriate material that is waterproof and non-conducting. It is desirable to make the surface of each barrier as spherical as possible since the presence of any sharp corners would lead to concentration of an electric field, and the undesirable scenario of a corona discharge. As can be seen from Figure 8, the electrical barriers in an embodiment of the present invention are semi-spherical in shape with slots where they are attached to

the spine of the neutral section 1. In an embodiment of the present invention, the barriers are spaced, and not necessarily periodically, at a distance of 100mm or greater. It has been found that, for the voltages that the neutral section 1 is subjected to when in use, a barrier spacing of less than 100mm becomes transparent to an electric field, which will "jump" this gap.

It can be understood that, when in use, the neutral section 1 is exposed to different environmental conditions. Specifically, it is undesirable if a condensation film should form on it since salt ions in the film would cause electrical discharge to occur from the outer surface of the neutral section 1. In order to avoid this scenario, a trace heater is incorporated into the moulding of the insulator 10 in an embodiment of the present invention. The function of the trace heater is best understood when the neutral section 1 is subjected to a "salt fog" test. This test involves exposing the neutral section 1 to a salt intensive vapour cloud in a specialised chamber so as to evaluate its discharge properties. The heater is used to increase the temperature of the neutral section 1 above the dewpoint temperature of the condensing vapour cloud so that it does not condense on the outer surface of the neutral section 1, or if it does, it evaporates quickly. Thus, by using a trace heater, it is ensured that no electrical discharge occurs from its surface due to the presence of a condensation film thereon when the neutral section is in use. The trace heater is a printed element on a substrate, for example, a 150 W heater element on a Kapton^{R} strip. Temperature limiting resistors are formed on the printed substrate bearing the heater and are connected in series to the heater. The non-linear dependence of the resistance of these resistors on the ambient temperature drastically limits the current flowing therethrough at high ambient temperatures, thus allowing the temperature of the neutral section 1 to be dynamically regulated and maintained at the same value in extreme environmental conditions. In an embodiment of the present invention, four such temperature limiting resistors are discretely formed along the length of the neutral section 1, at equal intervals, so that the neutral section 1 is maintained at the same temperature along its whole length.

Although a preferred embodiment of the invention has been described, alternative implementations are possible. For example, the connection member 2 need not be U-shaped and can be any other appropriate shape. Also, the connection member 2 can be lodged within the insulator via alternative means to the pegs 5 described hereinabove. If support is required in the mid-section of a neutral section 1 embodying the present invention, the neutral section 1 may be connected to an overhead catenary

system using insulation droppers attached to the spine of the section 1 via adhesive pads.